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The Effects of Regular Use of a Commercially Available Seating Device for Play on Obtainment of Fine Motor Milestones in At-Risk Infants

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This scholarly project reflects individualized, original research conducted in partial fulfillment of the requirements for the Occupational Therapy Doctorate Program, The University of Toledo.
Abstract

Objective: The purpose of this study was to determine if at-home use of a commercially available contoured foam seating device, specifically a Bumbo™ seat with tray, over time affords opportunity for fine motor development in infants born preterm who are not yet sitting independently.

Method: Six infants were randomly assigned to use a Bumbo™ daily for a month and six were randomly assigned to not use a Bumbo™ for a month (control). Pre- and post-tests were conducted using the Postural and Fine Motor Assessment for Infants-I (PFMAI-I, Case-Smith & Bigsby, 2000). Parents of infants in the intervention group were asked to log the daily use of the Bumbo™ for a period of one month. Both groups were asked to log the use of any infant positioning devices during this same month.

Results: From pre to posttest fine motor and postural skills improved equally in both groups. The average daily time spent in the Bumbo™ did not influence motor development on either the fine motor or postural scales. No correlations were found in changes in fine motor skill and average total daily use of equipment (R=0.088, p>0.05). Negative correlations were found with postural skills and average total daily use of equipment.

Conclusions: The results of this study provide no evidence to support the use of Bumbo™ seats to promote fine motor development in infants born prematurely who are not yet sitting. The negative correlation between postural development and use of equipment suggests that caution should be used when recommending equipment use. Further research is needed regarding the effects of seating equipment on the motor development of preterm infants.
The Effects of Regular Use of a Commercially Available Seating Device for Play on Obtainment of Fine Motor Milestones in At-Risk Infants

Fine Motor Developmental Milestones in Infants Born Preterm

The development of fine motor skills is a critical part of sensorimotor maturation and cognitive functioning in infants (Piaget, 1952 as cited in Hohenstein, Largo, Molinari, Kundu, and Duc, 1990). Goyen and colleagues (1998) found that 71% of premature infants with very low birth weight who appeared normal continued to have fine motor deficits at 5 years of age. Another study found that preterm infants born at less than 29 weeks gestation had lower eye-hand coordination and scores on the Peabody Fine Motor Scales compared to infants born full term (Goyen, Todd, Veddovi, Wright, Flaherty, & Kennedy, 2006). The development of fine motor skills tends to occur at a later age among preterm infants and often does not receive as much attention as other areas of development such as gross motor skills (Hohenstein et. al, 1990).

Since premature infants begin their life not fully developed, their motor and sensory systems are disadvantaged, leading to problems in development (Fallang & Hadders-Algra, 2005). According to Sangirardi Ganz (1990), control of the trunk and the shoulder are necessary to the development of reach and grasp; otherwise, the infant is required to use his or her arms for support rather than for playing. One factor that may contribute to the delay of fine motor skills is transient dystonia, a hyperextended posture of the trunk and neck (van der Fitts, Flikweert, Stremmelaar, & Martijin, 1999; Plantinga, Perdock, & De Groot, 1997; and De Groot, van der Hoek, Hopkins, & Touwen, 1992 as cited in van der Fitts et al, 1999).
Services for infants born preterm.

Since infants who are premature are at an increased risk for developing developmental delays, the American Occupational Therapy Association supports intervention, given to infant and family, to help prevent any delays. A prevention intervention can be used by occupational therapists before the onset of any delays to help enhance independence and decrease the onset of any delays (American Occupational Therapy Association, 1988).

Some 10 to 25% of infants treated at a Neonatal Intensive Care Unit (NICU) during the perinatal period go on to have neuromotor and/or developmental problems (Astbury, Orgill, Bajuk, & Yu, 1983; Coolman, Bennett, Swanson; Stave & Ruvalo, 1980 as cited in Gorga, 1989). Although these infants often do receive occupational therapy while in the NICU, they also can receive occupational therapy after discharge. The screening of high-risk infants in a follow-up program after discharge from NICU allows observation of how the infant is developing and so that the therapist can provide any recommendations that may be needed for an early intervention program (Gorga, 1989). Gorga suggests that one type of an early intervention program could be a short-term intervention program. A short-term intervention program provides guidance and encouragement to the family in helping to increase the development of their infant. Some infants may not require a long-term intervention program so a therapist can offer suggestions for home management.

Theories of Motor Learning.

The leading theory in infant development is the neuromaturation theory, reflected in the fact that that most assessments of infant motor development are based upon this
theory. This theory proposes that movement patterns that help an infant to have an upright posture and locomotion develop in a fixed order that is dictated by maturation of the brain and not influenced by the infant’s experiences (McGraw, 1945). Theorists hypothesize that brainstem structures develop first during motor development, which is apparent by a neonate’s automatic grasp and asymmetrical tonic reflex, and that cortical structures mature later (Case-Smith & Bigsby, 2000). Movement progresses from fundamental reflex patterns such as balance and postural reactions to voluntary, controlled movements allowing the infant to learn to roll, sit, stand, and walk (Case-Smith & Bigsby, 2000). The early motor reflexes serve as the infant’s first interactions with the environment. There has been increasing criticism, and supporting evidence thereof, against the ideas and assessments of this theory. Researchers have found that infants acquire motor skills at different ages, such that the sequence of motor development does vary among infants as opposed to being fixed (Case-Smith & Bigsby, 2000). For example, infants develop upright locomotion anytime between nine and six months of age (Stout, 1994). In addition, development has increasingly been shown to be influenced by an infant’s environment and experiences (Case-Smith & Bigsby, 2000).

A recent theory that takes these findings into account is the dynamic systems theory. According to this theory, the organization of movement appears to be a crucial aspect of motor skill that propels the infant’s development toward proficient performance (Case-Smith & Bigsby, 2000). Evidence suggests that the infant’s development depends as much on the demands of the task and environment as on the level of nervous system maturity so that movements are arranged and rearranged through adaptation of motor schemes. In contrast with neuromaturation theory, dynamic systems theory proposes that
motor behaviors are not produced in a top down manner in which the descending pathways of central nervous system alone dictate movement, but rather are generated in the brain but then modified by incoming signals from the visual, auditory, tactile, proprioceptive, and vestibular systems (Case-Smith & Bigsby, 2000). The various structures in the brain work together and are interdependent on each other in producing balance, postural stability, axial rotation, bilateral coordination, reaching patterns, grasping patterns, and motor planning (Case-Smith & Bigsby, 2000).

Current theorists have understood that movement patterns are highly influenced by the infant’s sensory experiences (Bradley, 1994; Heriza, 1991, & Piper & Darrah, 1994). The infant’s motor behaviors reveal the sensory preferences and the ability to understand the sensory input (Case-Smith & Bigsby, 2000). The sensory input helps the infant adjust finger movements and force to be able to grasp and manipulate an object, as well as develop an understanding of size, texture, and mass (Case-Smith & Bigsby, 2000). Any impairment in an infant’s responsiveness or perception of sensory stimuli limits refined movement patterns because of the imprecise feedback in the infant’s movement (Case-Smith & Bigsby, 2000).

**Postural Control and Hand Use**

Rochat and Goubet (1995) explored the relationship of postural control, reach, and hand use. The study consisted of three separate experiments. The first experiment tested the hypothesis that progress in control of upright sitting posture is followed by a change in the evolving reaching of the infants. There were two groups of full term infants, the “non-sitters” and the “sitter” infants. The infants were seated in an upright infant seat with armrests that were low. Each infant had four consecutive trials in which
they were presented with a colorful, hollow, plastic ball that produced sound when it was disturbed. The experimental trial ended when the infant either touched or grasped the object that was held by the experimenter. The results for successful reaches were 92% for the “non-sitter” group and 100% for the “sitter” group. In the second experiment a new group of non-sitter infants were placed in conditions with varying amounts of hip support (measured in mmHg and ranging from 0 to 40) while using the same reaching procedure as the first experiment. The hypothesis for this experiment was that the varying degrees of support provided to non-sitter infants would influence the coordination between the reaching action and the leaning of the trunk during reaching. The infants reached successfully in all of the postural conditions. Out of the 72 reaches, 54 of them were one-handed. The frequency of coordinated movements was calculated as the number of times there was a simultaneous decrease in hand-object distance from one video frame to the next during the two second approach phase of reach. “Non-sitter” infants showed an increase in the mean occurrences of coordinated movements in the 40mmHg hip support compared to the 0-mmHg and 20-mmHg conditions. In the 40-mmHg condition the “non-sitters” appeared to show the same mean frequency of coordinated movements between trunk and upper limbs compared to the “sitter” infants of the first experiment. The results support the hypothesis that varying degrees of hip support will influence the coordination in reach and leaning of the trunk. The hypothesis of the third experiment was that variability and skill in hand use and reach depend on the infant’s degree of self-sitting ability. This experiment involved three groups of “non-sitter” infants, “near-sitter” infants and “sitter” infants. The infants were again seated in an upright infant seat that had low armrests. They were presented with a white cardboard sheet covered with Velcro that
held all attached to a wooden structure that was held up by a tripod. In the familiarization trial, the display was presented out of reach of the infant and moved closer when the infant visually attended to it. This trial ended when the infant detached the ball from the display. 74% of all infants contacted the ball with their right hand. After this, the infant was then given the display with fifteen balls attached, with which the infant was free to interact. In this condition, “non-sitter” infants used their right hands to reach and their left hands to maintain balance, whereas the other two groups (near-sitter and sitter) used either hand. The lack of postural control is demonstrated in the infants’ ability to only use one hand when contacting the objects. Also, on average the “non-sitter” infants contacted the off-center balls with the opposite hand 37% of the time, whereas the “near-sitter” and “sitter” infants did so 10% of the time, indicating that the “non-sitter” infants cross midline to contact objects that are off center. These findings demonstrate that in order for young infants bring their hands into contact with objects the whole body must be engaged such that the attainment of self-sitting frees the upper limbs from the impediment of maintaining balance in an upright posture. This study raises the suggestion that providing external support when postural control has not yet developed can enhance reaching and hand use abilities. When the “non-sitter” infants were provided with external body support, they demonstrated a similar approach to “sitter” infants in the hand use and significant improvement in coordinated movements of trunk and limbs.

A study by Toledo & Tudella (2008) explored the development of reaching behavior in 5-7 month old infants who were born preterm compared to infants born fullterm. While in the seated position, kinematic variables were analyzed (i.e., straightness and adjustment indexes, movement unit, mean and final velocities). The infants were placed in an infant
chair angled at 50 degrees from horizontal with a retroreflective marker attached to their wrists (dorsal carpal region). In order to provide trunk stability, a strap was secured on the infants’ trunks. An attractive rubber object (toy) that was unfamiliar to the infants was used to encourage reaching movements. Researchers presented the object at midline, shoulder height, and arm length for two minutes and an interval of five seconds was allotted between each reaching movement. Therefore, the total number of trials was dependent on each infant. Outcome measures included kinematic variables, the adjustment index, and number of grasps. The adjustment index was calculated by determining the ratio between the time spent in the movement following the higher peak of velocity until the infant touched the object and the total duration of the reach; it specifies the proportion of time that was needed to decelerate the arm movement so that the hand touched the object. In both the preterm and fullterm infants, kinematic variables did not change over age, with the exception of the adjustment index, which was higher at 6 months in the infants born pre-term. When comparing kinematic variables between groups, there were no differences at 5 months. At the ages of 6 and 7 months, preterm infants demonstrated lower mean and final velocities and higher adjustment index when compared to infants born fullterm. In both groups, the grasping variable changed with age. In the preterm group, more successful grasps were demonstrated at 7 months compared to 5 months. In the full-term group, more successful grasps were found during sixth and seventh months when compared to 5 months. In the preterm infants, the proportion of grasps that were successful was negatively correlated with mean velocity. This negative association offers evidence that the lower the mean velocity, the higher the percentage of successful grasps. Taken together these results suggest that slower
movements and more adjustments may be functional strategies that preterm infants use in order to attain a successful grasp.

**Seating Devices and Postural Development**

Callahan and Sisler (1997) explored how frequently seating devices were present and used within the homes of infants not yet sitting independently. A questionnaire was conducted in 187 homes of infants younger than five months. Parents were asked about the availability of six seating devices (e.g., car seat, high chair, infant feeding seat, infant swing, walker, and stroller), as well as how much time the infant spent in each. Car seats were used with 183 infants, high chairs with 83 infants, infant seats with 144 infants, infant swings with 143 infants, walkers with 70 infants, strollers with 171 infants, cribs with 183 infants, and playpens used with 102 infants. Additionally, 94% of the infants spent 30 minutes or more in seating equipment each day. The average time spent in seating equipment each day was 5.7 ± 3.5 hours. Out of 187 infants, 42% spent 4-8 hours a day and 19% spent 8 or more hours in seating equipment. Car seats were found to be used 1 to 2 hours per day for 38% of the infants and 5% spent 3 to 4 hours a day. Car seats were found to be used the most by participants, followed by strollers, infant seats, infant swings, high chairs, and walkers. The findings from this study demonstrate that car seats were widely used by parents for the care of infants. The authors also discuss ways in which prolonged use of seating devices may have harmful effects on normal infant development. First, the mother has less physical contact with the infant that could impact infant development. Infants with gastroesophageal reflux have been shown to have more episodes when placed in infant seats compared to prone positioning (Orenstein, Whittington, Orenstein, 1983 as cited in Callahan & Sisler, 1997). Also, studies have
found that when premature infants were placed in car seats they demonstrated increased rates of hypoxemia, apnea, and bradycardia (Bass, Mehta, Camara, 1993; Willett, Leuschen, Nelson, L., & Nelson, 1989). Drawing from their study’s results and interpretations, Callahan and Sisler (1997) recommended that the use of car seats for safety of the infant while riding in a motor vehicle and the prolonged use of seating devices, specifically for infants not yet sitting should continue to be investigated in regards to impact on infant motor development.

Use of Positioning Devices with Premature Infants

   Occupational therapists may use seating devices during therapy to improve the posture of infants. The cited benefits of using a seating device are improvement in postural alignment (Miedaner, 1990) and facilitation of upper-extremity function (Myhr U, 1991). A study done by Washington and colleagues 2002, used four infants ages 9 to 18 months old who were not yet able to sit independently, had never used a contoured foam seating device before, and displayed the ability to reach out and grasp the toys that were at midline with either hand. The infants had varied diagnoses including spastic quadriplegia, Down syndrome, congenital hypotonia, and asymmetrical spastic quadriplegia. This study used three conditions including having the infants sitting in a regular highchair, a regular highchair with a thin foam liner, and regular high chair with a contoured foam seat (CFS), which was fabricated for each infant by a therapist who was part of the research team. The authors used a time series, alternating treatments design. The study examined what the effects of the CFS were on postural alignment and the effects on the infant’s ability to engage with toys. The researchers hypothesized that if infants had the ability to free their hands from the support of the highchair, they would
demonstrate improvement in postural alignment and would increase play with the toys. In order to determine the amount of engagement with toys, the number of hands that were in contact with a toy was measured, as well as the number of hands or forearm in contact with the highchair tray. For each infant the data was collected during a baseline phase for two five-minute periods with the infants seated in the regular highchair. The videotaping of the observation began immediately when an infant was given a toy. In the intervention phase data for the foam liner and CFS were collected once daily for eight days. The conditions for each day were randomized by the use of a coin toss and each infant served as their own control. The authors defined postural alignment as the organization of upper body segments over the pelvis allowing midline positioning in the frontal plane while sitting. Postural alignment was determined from videotapes using anatomical markers and visual cues placed on the back of the highchair. Engagement with toys was defined as the manipulation of a toy with one hand or both hands that included when an infant was playing with a toy, banging the toy on the highchair tray, and bringing the toy to his/her mouth. The results displayed a consistent effect of the CFS on improving postural alignment for all of the four subjects. However, the CFS did not have effects on the number of intervals of play using both hands in any of the subjects; however, two of the infants did show improvement in their ability to free their arms from support. The authors concluded that postural alignment was enhanced when infants who had neuromotor impairments were placed in a contoured foam seating device. This study also found that this type of device can provide an advantage by putting the pelvis in a neutral position and allowing the infant to have the ability to direct other segments of the body, such as the arms and hands.
In the study by Washington and colleagues (2002), all the mothers were given the contoured foam seat for daily use once all the videotaping sessions were completed. The mothers were asked to use the CFS at home for four weeks in the infant’s highchair, during which time the researchers ensured that any questions or problems that they were experiencing in using the CFS were addressed. After the four weeks, the mothers were interviewed with regard to the positive and negative aspects of the CFS. The mothers reported that their infants had increased independence in interacting socially, using their hands, and playing. A few mothers reported that when their infants used the CFS device they had showed improvement in manipulation with the toys and found new motor skills such as stabilizing the base of a pop-up toy with one hand and triggered pop-up figures with other hand.

Hohenstein-Thun and colleagues (1990) noted that there is limited amount of research on fine motor development in children born prematurely. The work of Washington and colleagues (2002) supports the use of positioning devices to encourage fine motor development in infants with neurological impairments. However, several factors limit the application of the findings to clinical practice with infants at risk for fine motor delay. Since the CFS was fabricated by an experienced therapist, the ability to generalize the findings to broad clinical practice is limited. Testing the use of a commercially available CFS device may allow greater clinical application. Also, the dependent measures used, freeing arm from supporting the trunk and hand-to-toy contact, focused on momentary availability of the hand for use, but did not require the infants to be successful in engaging with toys and as such, did not evaluate fine motor skills. However, with consistent use of the device in the home, mothers subjectively reported
improved fine motor skills and toy play abilities. The use of alternative dependent measures that tests variety, quantity, and quality of upper-extremity function after extended use of a CFS would be beneficial for future practical application. We seek to determine if at-home use of a commercially available CFS device over time affords opportunity for fine motor development in infants born preterm who are not yet sitting independently.

**Method**

**Subjects**

A convenience sample of 12 infants born preterm (6.8±2 weeks premature), ages 2.9±0.7 months old, gestational age, were recruited from infants who had been discharged to home from a Neonatal Intensive Care unit. All participants met the following criteria: (1) were unable to sit independently, (2) were able to fully support head, (3) did not demonstrate impairments of vision or hearing, (4) did not have major medical diagnoses, and (5) were willing to be randomly assigned to either study group. Participants were referred through early interventionists, participating agencies/facilities, or word-of-mouth. Prior to enrollment, informed consent was obtained from all the participants’ legal guardians.

Six infants were randomly assigned to use a Bumbo™ daily for a month and six were randomly assigned to not use a Bumbo™ for a month (control). There were no differences in gestational age (2.9±0.4 and 2.8±0.2 months for Bumbo™ and control respectively, p>0.05), prematurity (6.5±1.0 and 7.1±0.7 weeks, p>0.05), or postural maturity as measured by the Postural Fine Motor Assessment of Infants (scores of 38.3±2.9 and 42.7±3.4, p>0.05, see below for description of this assessment). Within the
Bumbo™ group, one infant demonstrated motor delay on both fine motor and postural scales. Two infants were at risk for motor delay on both fine and postural scales. One infant was at risk for motor delays on the postural scale, only. Within the control group, one infant was at risk for motor delay on both the fine and postural scales. Two infants were at risk for motor delay on the fine motor scale.

The socioeconomic status of participating families was obtained through a non-invasive questionnaire and categorized according to Hollingshead’s Four-Factor Social Index of Social Status (Hollingshead, 1975).

**Research Design**

The research design used in this study was an experimental design with randomized group assignment of each of the infants.

**Procedure**

To establish a baseline measure of motor development, researchers administered the Postural and Fine Motor Assessment for Infants-I (PFMAI-I, described below) at home to all of the infants participating in the study before randomization. The administration of the PFMAI-I was videotaped and took place in a quiet area. The videotapes of the assessment administration were used for the purposes of scoring and interrater reliability. The scores of the gross motor scale were used to describe the sitting abilities of participants. The scores of the fine motor scale were used as an outcome measure. The caregivers of infants whose scores fell outside of the typical range for their corrected age were recommended to follow up with their primary care provider regarding the risk for developmental delay.
The infants then were randomly assigned to two groups using permuted blocks. Parents of infants in the intervention group were given a commercially available CFS, specifically a Bumbo™ seat with a tray (Bumbo™ Pty, Ltd., Conroe, Texas, United States of America, See Figure 1 and description below), for use at home. The control group of infants were not given a seat and asked to refrain from use of a seat if they already had one in the home. The Bumbo™ seat with tray was provided to the caregiver, and the researchers provided individual education to each of the caregivers about the use of the Bumbo™ seat, including recommendations for the amount of time the infant should be placed in the seat, information about interaction techniques that may enhance developmental milestones while using the seat, and safety information regarding the usage of the seat. The safety information was consistent with the guidelines of the manufacturer of the seat. Educational methods included demonstration, verbal instruction, and written materials. Caregivers were assessed for their understanding through verbal exchanges. See Appendix A for materials to be provided to intervention participants. To control for the effect of receiving education related to their infant from a caring, educated student professional, the control group received education from the researchers related to the expected sequence of motor milestones and developmentally appropriate toys (Ohio Child Care Resource & Referral Association, 2006) but without any specific recommendations to follow. Parents of infants in the intervention group were asked to log the daily use of the Bumbo™ for a period of one month. Both groups were asked to log the use of any infant positioning devices during this same month. Participants in the Bumbo™ group reported 33.2±3.3 minutes of daily Bumbo™ use and 58.7±23.6 minutes of use of other equipment. Participants in the control group reported
67.8±26.7 minutes of equipment use. Total use of equipment was not different between the two groups (p>0.05). For both groups, equipment used included swings, car seats, high chairs, bouncers, strollers, exersaucers, and play gyms. See Appendix B for logs. Phone calls for both groups were made weekly during participation to ensure completion of the daily logs.

After one month, the PFMAI-I was re-administered to assess changes in sitting ability and as an outcome measure reflecting changes in fine motor abilities. The pre-to-post interval was not different for the two groups (30.7±1.4 and 30.5±1.0 days for Bumbo™ and control, respectively, p>0.05). At the post test, parents in the intervention group were asked to relate their experiences with the Bumbo™ through a series of questions, see Appendix C. The motor status of participants was assessed by use of PFMAI-I. Interrater reliability was assessed through having a trained second rater analyze 30% of videos. We report a linearly weighted kappa statistic. Interrater reliability for the primary outcome measure (fine motor scale) was κ=1.00, excellent agreement.

**The Bumbo™ seat**

The Bumbo™ seat is a commercially available seating device with a low, rounded seat and a midline pommel. Use of the seat places an infant into slight hip flexion, abduction, and internal rotation, putting the pelvis in a slight anterior tilt. The Bumbo™ measures 8” in width and the depth from the inferior edge of the pommel to the center back is 7 ¼” (Oakmann, n.d.). The height of the seat is 9” from the deepest point of the seat to the top of the back of the seat. The center pommel measures 3 ½” wide at the superior edge narrowing to 2”. The Bumbo™ weighs 3lbs. and is made of environmentally friendly polyurethane foam.
Postural and Fine Motor Assessment for Infants (PFMAI)

The PFMAI (Posture and Fine Motor Assessment for Infants) was designed by Case-Smith and Bigsby, 2000, to be used by occupational and physical therapists. The PFMAI is an early intervention assessment which qualitatively describes motor skills to provide a detailed picture of an infant’s abilities, as opposed to comparing the child to a schedule of developmental milestones (Case-Smith, 1992). The PFMAI is helpful in distinguishing and indentifying motor delays within infants and a measure that is sensitive in determining fine motor and postural progress with infants (Case-Smith & Bigsby, 2000). The PFMAI is divided into two age levels, and each level has a Posture Scale and a Fine Motor scale. The first age level (PFMAI-I) is for infant’s ages 2 to 6 months who are not yet able to sit independently. The second age level (PFMAI-II) is for infants 6 to 12 months who are able to sit independently. The PFMAI-I will be administered according to the instructions given in the manual, as follows. The assessment should take place in an environment with which the infant is familiar. The authors of the PFMAI-I find that testing environments that are familiar to the infant evoke the most accurate example of motor behavior (Case-Smith & Bigsby, 2000). For both scales the infant should be undressed to the diaper only. The parent/caregiver can be present during the assessment. Before initiating the assessment, the administrator should interview the parents about concerns and impressions regarding their infant. The questions should be open ended to allow the parents to independently identify the issues they have regarding their infant. General observations should be made at the beginning of the assessment to find out the infant’s sensory preferences.
The Fine Motor scale scores are reaching and grasping patterns, finger and thumb movements, release, and manipulation. The infants interact with three toys that differ in contour, size, mobility of parts, and visual and auditory features. These toys are used to help elicit various fine motor behaviors and responses, as well as, the use of both bilateral and unilateral hand use. The researcher will provide the toys or equipment which consist of red, one-inch cubes, a moveable parts toy (Discovery Toys ® elephant), red rings rattle (Johnson & Johnson Toys ®), and other toys that make sounds and are visually stimulating such as a stuffed animal, graspable toys and rattles, dangling links, a mirror, and an infant seat (Bumbo™ baby seat) to support the infant in sitting for play with the toys. The red cubes are used to elicit unilateral reach, palmar grasp, radial digital grasp, mouthing, and transfer. The elephant and red ring rattles are used to elicit bilateral reach, palmar grasp, radial or radial palmar grasp, bilateral hand play and transfer, isolated finger movements, and mouthing. The other toys are used to elicit an infant’s attention.

The PFMAI-I Fine motor scale items should be done while the infant is sitting in an infant seat, such as the Bumbo™ baby seat. The infant should be in a semi-upright position and should appear comfortable and stable. The objects should be presented to the infant one at a time at midline in space. The red cube is should presented on the palm of the researchers open hand. The rattles should be in the administrator’s fingertips so that they can dangle within the infant’s reach. The researcher can use vocalizations and pointing to direct the infant’s attention toward the object.

The purposes of the Posture scales examine postural control and proximal stability/mobility. For this study the posture scales will be used as a descriptor.
The PFMAI-I posture scales was designed for infants who are six months or younger and need external support to sit (Case-Smith & Bigsby, 2000). The infant is measured in both prone and supine positions. The infant should be observed for five minutes before scoring the test items. The infant should be placed on a blanket in the prone position with two bright colored and sound-producing toys in front of them. The infant should be observed for five minutes before scoring the test items. The infant’s head, shoulder, and pelvic movements will be facilitated by attracting the infant’s attention to the toys using the instructions given for the test items. If any items were not observed, the infant should be observed for an additional one to two minutes. After the prone position, the infant should be placed in a supine position on the blanket. The same movements will be facilitated. The objects should be presented several times to give the infant’s an opportunity to play and reach off the surface of the blanket.

Each item on the PFMAI-I fine motor scale and posture scale is scored 1, 2, 3, or 4 based on descriptions that are specific to each item where higher scores are indicative of greater abilities. If the infant only responds partially or very quickly a score should not be given for that response. Each object should be given a 4-minute period, then score the items for that toy. If the infant does not reach for the toy, it should be placed in his or her hand to score the grasping patterns. If the infant does not respond at all to a toy, it should be presented again for 1 to 2 minutes at the end of the testing period. In order to calculate the summary scores, all the items are scored and then the raw scores are summed for comparison to the fine motor scale. To determine if the infant’s motor function is typical, at risk, or delayed, the infant’s summary score is compared to criterion referenced scores for his or her age group, as summarized in Table 1.
Evaluation of inter-observer reliability was conducted for the PFMAI-I in two studies by Case-Smith (1989 and 1992). During both of the studies there were pairs of trained evaluators that observed the infants. One evaluator administered the items and each scored the items independently. The correlations were greater than .97 for both studied in each scale.

Test-retest reliability was conducted using the PFMAI-I. The study was done by Case-Smith, 1989, who found moderate to high test-retest reliability. The results for the posture scales were .90 and .49 for the fine motor scale. The scores in the fine motor scales are lower because they seem to be greatly influenced by the mood of the child, his or her interests in the toys, and arousal and attentiveness (Case-Smith & Bigsby, 2000).

Data Analysis

Data were distributed normally, allowing for parametric testing. The hypothesis that the use of the Bumbo™ would enhance obtainment of fine motor skills was tested using a two-way analysis of variance (2X2 ANOVA, with factors of time (pre and posttest) and group (Bumbo™ and control). Effect size is reported as partial eta squared (partial $\eta^2$). Motor development was quantified by change scores on the PFMAI-I. Correlations between change scores and average daily equipment use were assessed using Pearson’s. Significance was determined at the $\alpha=0.05$ level.

Results

Fine motor skills improved in both groups, Bumbo™ and control, equally from pre to posttest as indicated by main effects for time without a main effect of group or an interaction effect ($F(1) = 18.322, p<0.01$, partial $\eta^2 = 0.647$, a large effect, see Figure 2a).
Similarly, postural skills improved to the same extent in both groups (main effect for time F(1)=19.575, p<0.05, partial $\eta^2=0.662$, a large effect, see Figure 2b).

The average daily time spent in the Bumbo™ did not influence motor development on either the fine motor or postural scales, as assessed through correlation (R=0.181 and -0.407, respectively, p>0.05, see Figure 3).

As there were no differences between groups, data were pooled to assess for the overall effect of equipment use. Changes in fine motor skill did not correlate with average total daily use of equipment (R=0.088, p>0.05, see Figure 4a). In contrast, changes in postural skill negatively correlated with average total daily use of equipment (r=-0.579 (a moderate effect), $R^2=0.34$, p=0.049, see Figure 3b).

The infants in the Bumbo™ group who demonstrated a motor delay on both the fine and postural scales remained so at the end of the study, though scores in both categories improved relative to the cut scores. One infant in the Bumbo™ group who was at risk for motor delay on both the fine motor and postural scales had scores within the typical range at the end of the study. The other improved on the fine motor, but not the postural scale. The infant at risk for motor delay on the postural scale only remained so. The infant in the control group who began the study at risk for motor delay on both the fine motor and postural scales remained so. One of the infants who was at risk for delay on the fine motor scale improved to within the typical range. The other demonstrated a decrease in status to demonstrate motor delay. All parents of infants at risk or with motor delay at the beginning or the end of the study were informed and advised to follow up with their care providers.
Three parents in the Bumbo™ group reported additional benefits of using the Bumbo™ including helping to sit while engaging in feeding and play tasks, increased interaction within the environment, and assistance with head stability. All three parents also reported negative aspects of using Bumbo™ including difficulty with the infant holding his/her head up in the beginning of use, increased perspiration with diaper and clothes on, and lack of air flow around the backside area.

**Discussion**

This study offers no evidence to support the use of Bumbo™ seats to promote fine motor development in infants born prematurely who are not yet sitting. Obtainment of fine motor skills did not positively or negatively vary with Bumbo™ use. Nor did obtainment of postural skills. For all infants, use of equipment had no systematic relationship to fine motor development, consistent with similar findings from Washington and colleagues (2002); however, there was a negative correlation between postural development and use of equipment. This may suggest that increased use of positioning equipment negatively influences gross motor development, in which findings are varied. Two studies explored the impact of equipment use on infant motor development with healthy infants (Abbott & Bartlett, 2001; Fay, Hall, Murray, Saatdijan & Vohwinkel, 2006). One study (Abbott & Bartlett, 2001) found that infants who spent more time in equipment compared to infants who spent less time in equipment scored higher on motor development assessment. The other study (Fay et al., 2006) did not find a difference among motor development for users and non-equipment users. Another study (Callahan & Sisler, 1997) found that prolonged use of seating equipment for infants who are not yet sitting independently, may have a negative impact on motor development. Callahan et al.
(1997) suggest that the decreased amount of time that the mother has physical contact with the infant could possibly impact normal infant development. It is interesting to note that participants were not instructed to use the Bumbo™ in lieu of other equipment. Though their total use of equipment was not significantly greater than the control group, it did trend higher suggesting that they used the Bumbo™ in addition to, rather than instead of, other equipment. Given the negative correlation between postural development and equipment use, we suggest that when therapists do advise the use of specific equipment for a client based on their clinical reasoning, it may be best to instruct them to monitor total daily equipment use.

Although, no significant findings were demonstrated, it is important to discuss that three parents reported perceived benefits for their infant as a result from using the Bumbo™ seat with tray. These benefits included increased interaction within the environment and helping to sit while engaging in feeding and play tasks. The parents of one infant reported that he/she was not ready for using the Bumbo™ in the beginning of the trial because of inconsistent head control. This serves as a reminder to therapists that regular follow-up is necessary when recommending the use of a positioning device.

**Limitations**

There are multiple limitations of this study that need to be considered. The first limitation of this study was the small sample size demonstrating a risk of a Type II error. The small sample size also limits the generalizability of the findings. Another limitation of this study is the possibility of a ceiling effect. Only few of the infants demonstrated a motor delay at the beginning of the study such that improvement could not be expected regardless of the intervention. Another limitation of this study was the heterogeneity in
developmental status of each of the participants. Infants born preterm generally develop at a later age (Thun-Hohenstein et al., 1991) and each will develop motor milestones at a different rate. Some premature infants will achieve motor milestones closer or further from their adjusted age. Lastly, the impact of the environment (e.g., time of day, noise distractions) and physical status of the infant (e.g., tired, hungry, sick) may have impacted the child’s interaction and motivation to participate at the time of testing.

**Future Research**

The findings from this study suggest numerous directions for future research. First, future research could include only infants who have more significant delays at the beginning of study. This may provide opportunities for increases in change scores on either postural and/or fine motor development. Second, extending the duration of the intervention would increase the intensity of the use of the Bumbo™ allowing more opportunities for the parents to incorporate feeding and play tasks. Third, future studies should investigate the effects of other seating devices on motor development that are commonly used within the home (e.g., exercaucers, bouncers). Additionally, a larger number of participants is needed. Given the low correlations demonstrated in this study, it is suggested that more extensive longitudinal research is needed regarding the use of a Bumbo™ on the obtainment of fine motor skills in preterm infants not able to sit independently.

**Acknowledgements**

We would like to express sincere appreciation to Mercy Children’s Hospital, Neonatal Follow-up Clinic, specifically Jenny Lietaert, PT for her assistance with
recruiting families for participation in this research. We would also like to thank all the families for taking the time to participate in our study.
References


Table 1

*PFMAI-I Scoring Categorizations*

<table>
<thead>
<tr>
<th>Age</th>
<th>Scores indicative of typical development</th>
<th>Scores indicative of “at risk” for fine motor delay</th>
<th>Score indicative of fine motor delay</th>
</tr>
</thead>
<tbody>
<tr>
<td>2-3 months</td>
<td>24-33</td>
<td>≤23</td>
<td>Not applicable</td>
</tr>
<tr>
<td>4 months</td>
<td>43-50</td>
<td>36-42</td>
<td>≤35</td>
</tr>
<tr>
<td>5 months</td>
<td>61-68</td>
<td>53-60</td>
<td>≤52</td>
</tr>
<tr>
<td>6 months</td>
<td>62-71</td>
<td>53-61</td>
<td>≤52</td>
</tr>
</tbody>
</table>
Motor development, as measured by the PFMAI, before and after a month of regular use of a Bumbo™ (experimental group, n=6) or refraining from use of a Bumbo™ (control group, n=6). A. Fine motor scores showed a main effect of time ($F(1)=18.322$, $p<0.01$, partial $\eta^2 = 0.647$, a large effect) B. Postural scores showed a main effect of time ($F(1)=19.575$, $p<0.05$, partial $\eta^2=0.662$, a large effect).
Figure 3. Effects of Bumbo™ use on Motor Development in Experimental Group

A.

Fine motor

Correlations between change scores on the PFMAI with average daily time spent in the Bumbo™ seat for participants in the experimental group. Neither Fine Motor change (A) nor Postural change (B) correlated with Bumbo™ use.
Changes in motor skill plotted against average daily time spent in positioning equipment. Correlations were assessed on the pooled sample. Groups have been indicated separately to show the overlapping distribution of average time of equipment use. A. Fine motor changes did not correlate with equipment use. B. Postural changes were negatively correlated with equipment use ($r=-0.579$, $R^2=0.34$, $p=0.049$).
Recommendations

Our Bumbo can be used for:

Inform play

- Toy play
- Drop & manipulation of
- Encouraging reach, grasp

- Interactive play
- Your infant play with toys
- Where you feel you and

- Exploratory play
- Togetherness your infant play with toys
- Where your infant explores

- Where your infant explores

- Feeding (if infant has begun
- Loss of his or her own

- Spoon feeding or folds finger

Safety First

When using the Bumbo, NEVER
*Recommended Toys for Use with the Bumbo™ Seat for Infants 2-6 months*

- **Cloth blocks**
  - Encourage reaching (one or both hands)
  - Encourage various grasp patterns (whole hand, finger tips only, just thumb and two fingers, etc.)

- **Link Rings & Teethers**
  - Shake and rattle
  - Bang
  - Explore with mouth

- **Mirrors (edges completely enclosed)**
  - One that your infant can hold or suctions to the Bumbo™ tray

- **Variety of Balls (balls that are see-through, various sizes, shapes, colors, textures)**
  - Encourage reaching
  - Pass from hand to hand
  - Drop or let go of
  - Bang together
  - Bang on tray

Note: Fine motor skills of your infant will depend on their age
### Appendix B

**Time in Seating Equipment Daily Log**

<table>
<thead>
<tr>
<th>Date:</th>
<th>Example:</th>
<th>Time in equipment</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>June 6, 2009</td>
<td>1. 10 min at 9:00am Bouncer</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2. 15 min at 5:30pm Walker</td>
</tr>
</tbody>
</table>

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**Time in Bumbo™ Daily Log**

<table>
<thead>
<tr>
<th>Date:</th>
<th>Example:</th>
<th></th>
<th></th>
<th></th>
<th></th>
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<tr>
<td></td>
<td>June 6, 2009</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Time in Bumbo™**

1. 15 min at 7:30am  
   Toy Play
2. 15 min at noon  
   Exploratory Play
3. 15 min at 6:30pm  
   Toy play

**Time in equipment**

1. 10 min at 9:00am  
   Swing
2. 15 min at 5:30pm  
   Play gym
Appendix C

Thank you for participating in our study. We’d like to know how your experience with the Bumbo® has been.

Please use the following ratings to respond to the questions below.

<table>
<thead>
<tr>
<th>Strongly agree</th>
<th>Agree</th>
<th>Neutral</th>
<th>Disagree</th>
<th>Strongly disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
</tbody>
</table>

1. I was comfortable using the Bumbo® with my infant

2. The Bumbo® seat provided my infant with more opportunities to interact and play with his/her toys

3. Over time, I saw improvements in my infant’s ability to manipulate toys or other small objects

4. The amount of time recommended in the Bumbo® was appropriate

5. Overall, using the Bumbo® fit into our daily routine

Please comment on any additional benefits you found in using the Bumbo®

Please comment on any negative aspects of using the Bumbo®

Approved by University of Toledo IRB

Assigned Version Date: 03/03/2010